Performance Evaluation of Power Quality Mitigating Equipment : A Case Study of Uninterrupted Power Supply (UPS) Applications in Ilaro

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Abstract

This paper evaluates the performance of common and popular brands of uninterruptible power supply in commercial sectors as power quality (PQ) mitigating equipment. The study was carried out in two phase. In the first phase, a sample of commercial users of UPS was collected from the population of users through a survey method and data collected were analyzed. The primary data were garnered using a well-structured questionnaire about UPS and field measurements. Descriptive statistics such as frequencies and bar chart were used in the analysis of data obtained from the survey. Also, series of tests were carried out on two brands of UPS (i.e. Mercury and Zinox brand of UPS) in order to ascertain their operating parameters against the standard.

The survey shows relatively high rating of UPS as PQ mitigating equipment by the end-users. Also, the performance test carried out shows that they met the required standard and that locally branded type competes favourably with the foreign type. Appropriate recommendations were therefore made to ensure that both locally and imported manufactured UPS conforms to the required standard.

Introduction

Power quality issues arise as a result of the modern day equipment requiring adequate and clean power supply free from distortion and fluctuation. In Nigerian electrical network, usually because of long line from generation to distribution, voltage drop at end-user is common experience. Apart from irregular supply of power which has characterized the electricity supply in Nigeria and other developing countries in Africa; voltage fluctuation, flickering are other phenomena associated with distribution network. Thus, the overall power quality provides by Nigeria electric utility boards does not provide a clean power free from surge and sag in voltage, frequency variation, spikes , transient and harmonics. Hence consumers that are using sensitive loads have to depend on power supply conditioning equipment such as UPS. The reason being that such electronics equipment like computer (including all data processor) and energy saving devices like compact fluorescent lamp (CFL)often refer to as critical loads are classified as non-linear load which draw distorted waveform from the supply [1]. Therefore, mitigating equipment such as uninterruptible power supply (UPS) is needed. The use of UPS in mitigating PQ has been widely reported in literatures [2]. Considering the important roles such equipment plays on critical loads, it is therefore the utmost importance to evaluate their performances. There has been increasing awareness of PQ problems across the globe [1, 3]. PQ survey has been employed as part of seeking solution to PQ problem globally [4]. The report of study conducted in 1,400 sites in 8 European countries in 2001 has been well documented [5]. Similar survey in Asia has been reported [6]. The choice of UPS is usually based on ability to sustain power for sufficient period during interruption of the main supply. Also, it is expected

that the output from the UPS is free from voltage fluctuation and other similar PQ problems. Part of PQ solution is customers' satisfaction [7]. As End-users experiences are therefore necessary for evaluating the performance of UPS. There is also need to ascertain their performances by field measurement.

Methodology

The study was carried out in two phase. In the first part, it was by administration of questionnaire to a set of commercial Business Centres that use UPS in order to extract the needed information. The population study was limited to Ilaro, Yewa South Local Government in Ogun State in which forty commercial users of power supply conditioning equipment (i.e. UPS) were selected using a sampling technique. A set of Key Performance Index (KPI) was used in the evaluation and the expected responses are stated in Table3. In the second phase, performance test was conducted on two of the popular brand. Mercury and Zinox brand of UPS were selected to carry out the field test to verify some UPS parameters against standard value. The choice of Mercury brand of UPS was because of its growing popularity and also to compare foreign-made with locally made Zinox brand.

Therefore, the primary data obtained were from the survey and series of test carried out on the mercury and Zinox brands of UPS. The test was carried out with the aid of instruments such as multimeter, frequency meter and stop watch. The parameter measured includes the input and output voltage; frequency, reserve time and the rate of voltage drop across the battery when connected to a load. The rating of mercury and Zinox brand of UPS used for the test was 500VA. The supply voltages to each brand of UPS were measured and output voltage for each also measured with frequency. In order to determine the reserve time, each UPS was connected to a particular load one at a time and time to discharge was recorded with voltage drop. Each UPS was tested for a period of twenty eight minutes, thirty eight seconds (28:38:20s) after being fully charged. Measurement was taken at an interval of two minutes.

Data Analysis and Result

The data obtained from the survey showed a good representation of male and female composition of respondents with majority having more than three years of experience in UPS applications. The results

of the survey are presented in bar graph of figure 1 to 8 as follow:
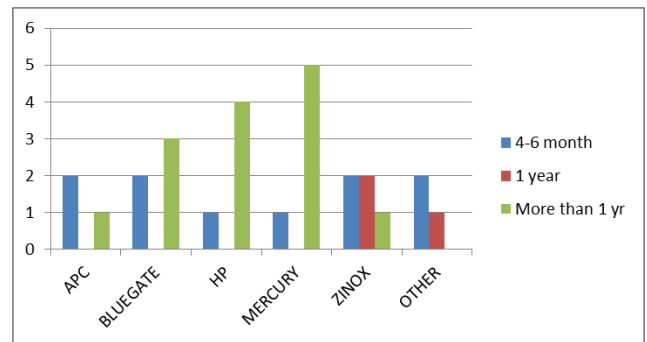

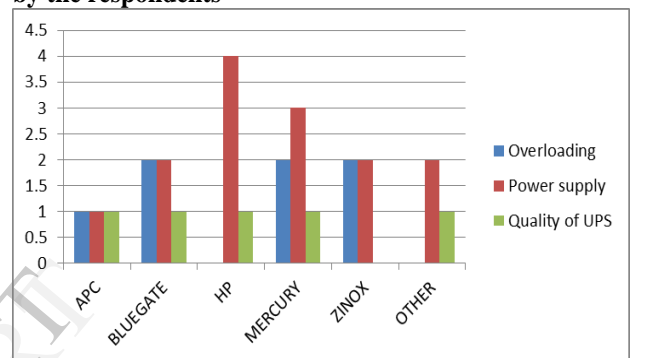**Fig 1: The perceived MTBF of each brand of UPS by the respondents**

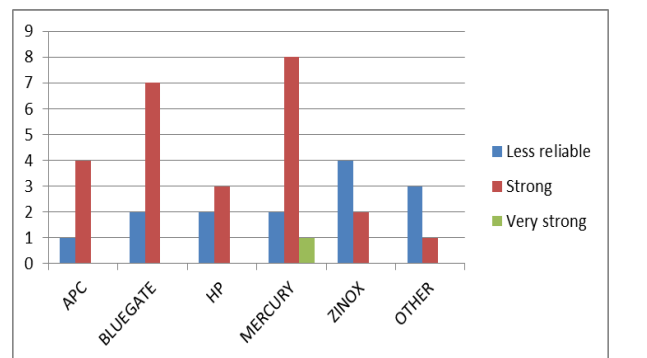**Fig2: The respondents' perception of causes of breakdown of their UPS**
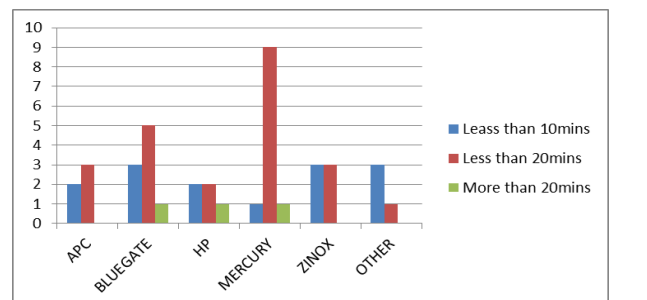

Fig 3: The reliability perception of the respondents

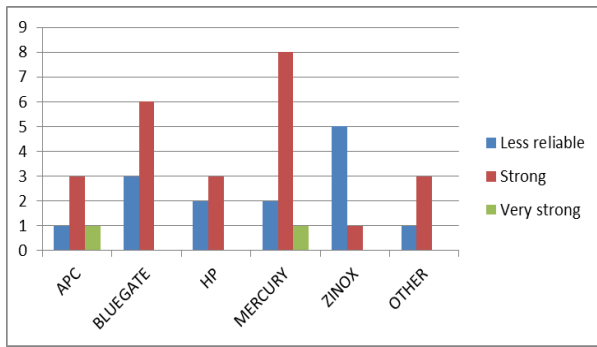**Fig 4: The duration of UPS operation after interruption of the main.**
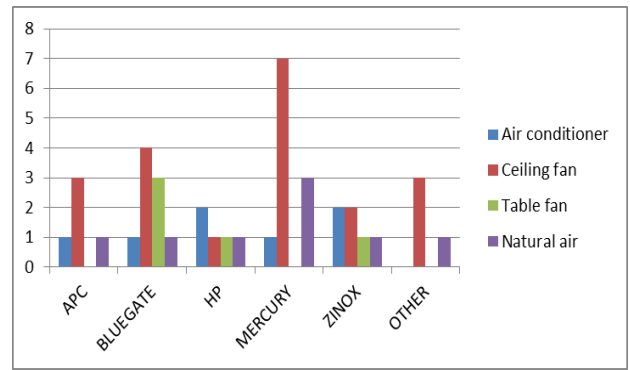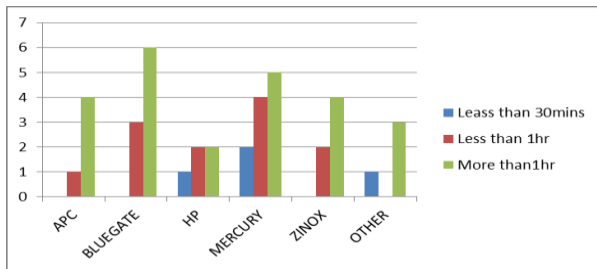
Fig 5: The durability perception of the respondents

Fig 6: The duration of charging after completely drained.

Fig 7: The numbers of respondents using AVR (stabilizers) with UPS
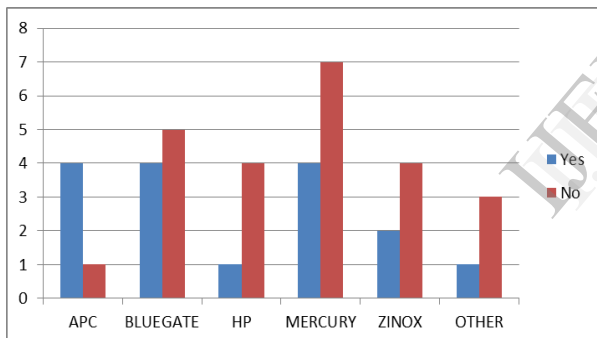
Fig 8: The cooling methods used by the respondents

Data from Test Carried-Out on UPS

From the measurement taken, the readings obtained from test carried out on UPS are shown in tables 1& 2.

Table 1: Electrical Parameters of the UPS

Brand	Supply Voltage (V)	Supply Frequency (Hz)	Output Voltage (V)	Output Frequency (Hz)
Mercury	232	49.8	230	49.18
Zinox	232	49.8	230	49.05

Table 2: Discharge voltage with time for the UPS's

Time (minutes)	Voltage (V)	
	Mercury brand	Zinox brand
0	12.13	12.05
2	11.96	11.86
4	11.78	11.69
6	11.62	11.57
8	11.45	11.32
10	11.28	11.14
12	11.12	10.96
14	10.94	10.76
16	10.77	10.59
18	10.62	10.42
20	10.45	10.24
22	10.28	10.05
24	10.12	9.98
26	9.95	
28	9.80	

The plots of Table 2 are as shown in figure 9 for the two brands of UPS.
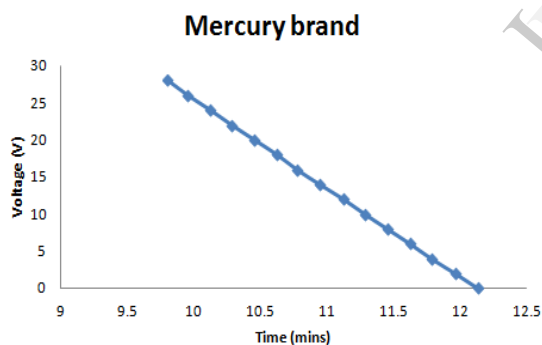
Fig 9: Discharge voltage versus time curve for Mercury
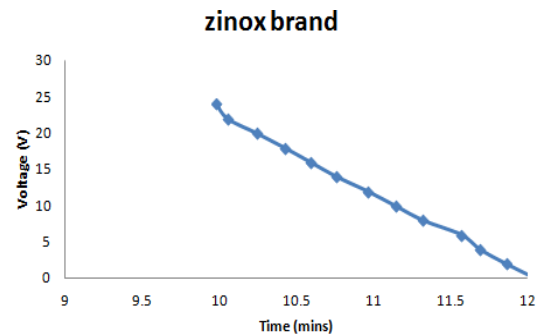
Fig 10: Discharge voltage versus time curve for Zinox brands

Discussion

From the result obtained from the field survey, it was gathered that the popular brands of UPS used by the commercial users of UPS in Ilaro are APC, Bluegate, HP, Mercury and Zinox.

The study reveals quite a number of information on the strength and acceptability of different brands of UPS assessed. The MTBF of one year or more is more than those with less than one year with greater cause attributed to power supply. Similarly, the durability and reliability perception are very high. It was observed that majority of the respondent used only ceiling fan for cooling without using automatic voltage regulator (stabilizer). Thus it can be said that the equipment are rugged and able to withstand environmental and electrical effects. The Mercury brand appeared to be the most popular.

From the performance measurement carried out, the full charging voltage for Mercury brand is 12.13V while that of Zinox is 12.05V. The voltage at which the UPS (Mercury brand) battery stops supplying is 9.80V while Zinox stops supplying at 9.98V (24:15:92s). The test shows that, depending on the load and battery, the reserve time of the UPS is enough for orderly shut-down of a system when there is power failure. Also, the frequency of the UPS is found to be 49.18Hz which makes it to conform with the required range +/-0.5%.

Conclusion

The study has evaluated the performance of UPS as PQ mitigating equipment. The survey shows relatively high rating of UPS as mitigating PQ mitigating equipment by the end-users. Also, the performance test carried out shows that they met the required standard and that locally branded type competes favourably with the foreign type.

Recommendation

Manufactures of UPS should be aware of power supply problems and thus design their equipment to be more rugged. Power surge protector should be used with all UPS in order to prevent damage due to variations in supply voltage. Commercial user of UPS should adhere strictly to the instructions on the UPS manual. The standard organisation of Nigeria (SON) should ensure that both imported and locally manufactured UPS conform to the require standard.

References

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Appendix

The Key Performance Indices questions used for evaluation of UPS

S/N	Key Performance Index	Response			
1	The perceived MTBF of each brand of UPS by the respondents	4-6 Months	1 Year	More Than 1Year	
2	The respondents' perception of causes of breakdown of their UPS	Overloading	Power Supply	Quality of UPS	
3	The reliability perception of the UPS by respondents	Less Reliable	Strong	Very Strong	
4	The duration of UPS operation after interruption of the main	Less Than 10mins	Less Than 20mins	More Than 20mins	
5	The durability perception of the respondents	Less Reliable	Strong	Very Strong	
6	The duration of charging after completely drained	Less Than 30mins	Less Than 1hr	More Than 1hr	
7	The numbers of respondents using AVR (stabilizers) with UPS	Yes		No	
8	The cooling methods used by the respondents	Air Conditioner	Ceiling Fan	Table Fan	Natural Air